Diskussionspapiere
Discussion Papers

Discussion Paper No. 204

Money Demand in Europe:
Evidence from the Past

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Berlin, April 2000

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ISSN 1433-0210

Money Demand in Europe: Evidence from the Past *

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Abstract

The conditions under which European monetary policy is likely to be conducted are investigated by means of multi-variate time series modelling using aggregated data of all eleven European Monetary Union member states. A cointegration analysis identifies two stable long-run relationships within a set of five key macroeconomic variables, one of which can be interpreted as a money demand function and a second one as a long term real interest rate (Fisher parity). Our findings indicate that monetary authorities might well be able to base their policy on the existence of a money demand. Particular emphasis is given both to the data sources and their aggregation, by providing a transparent account of our calculation procedure, which is not yet common in the existing literature.

*We thank Helmut Lütkepohl, Jürgen Wolters and Jörg Breitung for many helpful comments. We are indebted to Katja Rietzler for her support in constructing the GDP data. Of course, all mistakes are ours. Financial support from the Deutsche Forschungsgemeinschaft, SFB 373 is gratefully acknowledged.

1 Introduction

When the idea of a single currency for Europe won more and more followers, economists shifted the focus of their research to the conditions under which a European monetary policy would likely have to be conducted. One of the research interests focused on whether or not a European money demand is stable and whether or not a more stable money demand on a European level compared with national findings is a statistical artefact (see e.g. Arnold (1994), Artis, Bladen-Hovell and Zhang (1992)).

By now there is widespread acceptance that European policy decisions have to be built upon the data available so far, regardless of the impact of a possible change in agents behaviour which could have been induced by the start of the European Monetary Union (EMU). Such a change in conditions will only be apparent after some time. Therefore, from an empirical viewpoint, the best one can do is to look at Europe as an economic union which, in principle, works like a large national economy.

For the first time Kremers and Lane (1990) estimated a European money demand by aggregating national data sources. So far, most studies have focused on a limited set of countries, mainly the larger or core countries of the EMU (see e.g. Wesche (1998), Hayo (1999), Monticelli and Strauss-Kahn (1993) Fagan and Henry (1998) to name only a few). We estimate a money demand function for the eleven EMU-countries. To our best knowledge only Gottschalk (1999) and Coenen and Vega (1999) have chosen the same group of countries. In addition we present a detailled account of our data sources and aggregation methods. Doing so we want to provide the most possible transparency of our calculation procedure, which is not yet common in the literature.

The structure of the paper is as follows. We first discuss advantages and drawbacks of relying on aggregated artificial data referring to the time prior to the European Monetary Union (EMU), then outline in detail the data sources and aggregation methods we use to collect a data set for analyzing money demand properties of the area of the EMU member states. We find it not reasonable to go much further back in history than 1984 because data quality and availability deteriorates rapidly prior to that date.

The second part of the paper is a cointegration analysis of money, income, long and short term interest rates and prices within a Vector auto-regressive Error Correction Model (VECM) in order to investigate the conditions for European monetary policy. The focus will be on long-run money demand, which we are able to identify and, moreover, find to be stable.

A comparison with studies referring to the same set of countries, discussion of our findings and of likely consequences for policy making as well as suggestions for an agenda for future research will close the paper.

2 Special Problems concerning Aggregated Money Demand Functions for the EMU

Economists who attempt to estimate a money demand function for the EMU are facing a number of special problems. These have arisen because the EMU began just one year ago and so no long time series data for it exists. One common solution is to rely on artificially constructed EMU data that are generated by aggregating the national data of the participating countries for the time prior to the EMU. In constructing these data one faces on the one hand problems with the availability and the quality of the data used and on the other hand special problems concerning the appropriate aggregation method. The issue of the availability and the quality of the data used is discussed in section 2.1 below. The question of the appropriate aggregation method did not rise for our money demand investigation because we used the official monetary aggregate for the EMU that was constructed by the European Central Bank (ECB) itself. Paying attention to consistency when aggregating different data series, we constructed our other EMU series in the same way as the monetary aggregate. We therefore refrain from conducting a detailed discussion of the advantages and disadvantages of different aggregation methods. Alongside this issue the interpretation of the results achieved with this artificial, aggregated EMU data poses some special problems that are the subject of section 2.2.

2.1 Availability and Quality of the Data

Estimating a money demand for the EMU means estimating an aggregated money demand that comprises the data of 11 countries.[1] Providing sufficient time series covering long periods for all variables included in the money demand for all EMU countries turns out to be quite difficult especially since the EMU area also comprises countries for which no extensive and detailed statistical data is available. Therefore a considerable amount of estimation, particularly in the earlier part of our data sample was unavoidable. The construction of the EMU data will be discussed in detail in section 3.2.

Furthermore, distortions in the EMU data are an important issue. Different sources of impairment can be identified for the EMU data. Firstly they can be biased because the underlying national series by themselves are distorted, for example, because of structural breaks. A second reason for distortion in the aggregated data lies in the fact that this data often refers to non-harmonized national data. The national time series are based on national data definitions which can vary significantly between countries. For instance different calculation methods of Gross Domestic Product (GDP) or different maturities of the assets the interest rates refer to are underlying the aggregated EMU data. A further harmonization problem arises because original, non-seasonally adjusted national data is not published for all countries joining the EMU and different procedures of seasonal adjustment are applied in different countries.

[1] These countries are Belgium, Spain, France, Ireland, Italy, Luxembourg, Austria, Netherlands, Portugal, Finland and Germany.

2.2 Interpretation Problems

The interpretation of the results achieved with the artificial EMU data has to be taken with caution. The question which arises is to how relevant the results and conclusions drawn from these artificial data of the past are for the time period after the start of the EMU. Here it is essential to distinguish between the relevance of the results based on past data for the time period after a potential structural break in general and the relevance of the results referring to the artificially generated aggregated EMU data for the time period after the start of the EMU in particular.

2.2.1 Inference for the EMU from Past Data

A general statement concerning the transferability of the results achieved before a regime shift to the time period following the regime shift is related to the Lucas (1976) Critique . This implies that since a regime shift like the introduction of the EMU and the start of a common monetary policy in the EMU countries can induce changes in agents' behaviour, it is not compelling that conclusions drawn on the basis of past data are valid also for the time period after the regime shift. Using this approach, it follows that results obtained from our past aggregated EMU data for the money demand in the EMU have to be interpreted carefully.

A potential source of a structural break in agents' behaviour is a change in the monetary conditions present in the countries joining the EMU. The convergence process of monetary conditions of countries participating in the EMU took place within the time period that underlies our investigation which comprises the years from 1984 to 1998.[2] This implies that a change in the behaviour of individuals may have taken place within our estimation sample that could exert an influence on money demand and its stability properties. Against that, the monetary conditions at the end of our estimation sample compare to those after the start of the EMU. Therefore a change in the behaviour of individuals at the very day of the introduction of the Euro due to changing monetary conditions does not seem to be likely. Subsequently the results obtained in our investigation should provide us with some evidence about the conditions beyond that date.

Further arguments in favour of the relevance of the results based on past data for the EMU regime are brought up by Hayo (1999). Firstly, he suggests that the economic shock on money demand induced by the start of the EMU could possibly be only of temporary nature as was also often pointed out for the shock brought about by the German monetary union. In this case monetary policy in the EMU can rely on the results achieved on the basis of the past data. Secondly, he assumes that people adjust their behaviour to the new monetary environment only very slowly. If this behavioral inertia proves right, past experiences will be applicable to the EMU regime at least for some time.

[2] This can easily be seen by comparing, for instance, the inflation rates or the interest rates between the EMU countries both at the beginning and at the end of the period under consideration. At the beginning enormous differences show up while at the end convergence seems to be achieved.

2.2.2 Inferring from Aggregated Artificial EMU Data

Besides the general problems of transferring results achieved before a (potential) structural break to the time after, evaluating the money demand and its properties in the EMU on the basis of artificially aggregated data is accompanied by additional problems.

A special property of aggregated money demand functions seems to be that they exhibit better stability properties compared to national functions.[3] This leads to the question as to whether the enhanced stability properties will be maintained after the start of the EMU, since EMU money demand exerts in some way properties similar to national functions.

One possible explanation for the observed better stability properties of EMU money demand could be that negatively correlated national shocks compensate each other. However, if this should prove to be the reason for the enhanced stability properties, the stability of money demand is likely to deteriorate after the start of the EMU since national shocks, especially monetary shocks, will occur more synchronised within a monetary union.

The better stability properties of the aggregated EMU money demand could also be due to a superior specification of aggregated money demand functions compared to national functions. The specification bias caused by omitted variables such as currency substitution which constitutes a frequent source of distortions for national money demand functions, is of minor importance for aggregated money demand functions, since for larger areas foreign influences are often included automatically. For instance, for the aggregated EMU money demand the problem of currency substitution, as far as it refers to European currencies, is solved solely for reasons of the new definition of the monetary aggregate M3 of the ECB.

It is not clear, however, if the better stability properties of EMU money demand, that refer to a superior specification of EMU money demand, will remain after the EMU has began. Future instability can certainly not arise from currency substitution between Euro countries yet may be introduced by substitution between the EMU area and the rest of the world.

Furthermore the introduction of a single currency in Europe enhances competition between countries not only on the goods market by improving price transparency but also at the financial markets. This spurs the development of financial innovations within the EMU, which could exert a negative effect on the stability of money demand in the future as well (see Hayo (1999)).

All in all it is difficult to say if money demand and its properties are going to change in transition to the EMU. While a number of arguments seem to indicate a change in individuals behaviour others seem to reject it. In any case the results and conclusions taken on the basis of the past aggregated data of the countries joining the EMU have to be interpreted with caution.

[3] See e.g. Kremers and Lane (1990), Monticelli and Strauss-Kahn (1993), Artis et al. (1992) and Monticelli (1996) in favour of that hypothesis and Arnold (1994) in opposition to it.

3 The Money Demand Function and the Data

This chapter is devoted to the specification of the money demand function and the choice of variables that should enter this function. Furthermore a detailed description of the construction features of the aggregated data for the eleven EMU countries is given.

3.1 The Money Demand Function

In empirical investigations on money demand usually the demand for real money is estimated. There are two reasons which imply the specification of demand for real money. The first relies on economic theory; money is in general supposed to be neutral in the long run, consequently long run price homogeneity is assumed. The second reason is based on econometric grounds. In most econometric investigations nominal money stock as well as the price level are found to be not only non stationary but even I(2). In line with these results lies the fact that the demand for real money usually shows up as I(1), i.e. a cointegration relationship between nominal money demand and the price level exists. As econometric modelling with I(1) variables is supposed to be easier than with I(2) variables, estimating the demand for real money is generally preferred and will also be applied in this paper.

Economic theory suggests different reasons for holding money. Two main purposes for holding money can be distinguished. On the one hand money is held for transaction purposes. On the other hand holding money is part of the optimal portfolio selection. In our money demand specification we use a broad monetary aggregate since the ECB decided to target the broad monetary aggregate M3. The transaction motive of holding money is represented by real GDP. A long term interest rate, a short term interest rate and the inflation rate are added as portfolio choice variables. The long term interest rate measures the rate of return to financial assets not included in the monetary aggregate whereas the short term interest rate can be interpreted as a proxy of the own rate of return – this concept is consistent with the employed broad monetary aggregate – and at the same time as a policy variable. Alternatively, the interest rate spread could be applied to model the opportunity costs of holding money compared with other financial assets. Furthermore, the inflation rate reflects the opportunity costs of holding money contrary to holding real assets.

Equation (1) comprises our specification of the long-run money demand function.

$$M^d/P = f(Y, i^l, i^s, \pi) \tag{1}$$

M^d, P, Y, i^l, i^s, π represent the nominal money demand, the price level, the real GDP, the long term interest rate, the short term interest rate and the inflation rate respectively. For a better interpretation of the estimated coefficients, a log-linear form of the money demand function is applied as illustrated in equation (2)

$$(m-p) = \beta_y y + \beta_{i^l} i^l + \beta_{i^s} i^s + \beta_\pi \pi + ec_m \tag{2}$$

where lower cases m, p, y indicate logarithms, while the interest rates are expressed in levels. The error correction term is denoted ec_m. The coefficient β_y represents the income elasticity of the demand for money. It should show a positive sign; as income increases so does the transaction demand for money. Corresponding to the quantity theory this elasticity should equal unity, while the Baumol-Tobin theory of money demand suggests a coefficient of 0.5. Conversely in other empirical investigations on the demand for broad money the coefficient often exhibits a value that exceeds unity. This value compares to the observation of a trend decline in the velocity of circulation. It can be explained by financial innovations and wealth effects, which are not explicitly modelled. Higher wealth leads according to the optimal portfolio selection to higher investment in all assets including those short term assets that are part of the money demand.

The coefficient β_{i^s} reflects the semi-elasticity of money with respect to the short term interest rate. This coefficient should exhibit a positive sign since a higher rate of return of the short term assets included in the monetary aggregate increases their attractiveness compared to other assets. On the contrary, an increase in the long term interest rate induces portfolio shifts towards longer term investments, which reduces the demand for money and corresponds to a negative sign of β_{i^l}, the semi-elasticity of money with respect to the long term interest rate. If the coefficients β_{i^l} and β_{i^s} have the same magnitude and opposite signs, they can be interpreted as the opportunity costs of holding money compared to other financial assets, which constitutes an alternative modelling possibility. The semi-elasticity of money with respect to the inflation rate, β_π, should show up as negative since an increase in the inflation rate reduces the value of monetary assets. The inflation rate therefore represents the rate of return of real assets compared to nominal assets.

3.2 The Data

The estimation and test results are sensitive to the construction of the data in general and the employed aggregation method in particular. Therefore the construction and aggregation procedure of the EMU data underlying this investigation is an important feature and is described precisely in the following.[4] The analysis is based on quarterly data that refers to the time period from 1984(1) to 1998(2). To cater for lags and differenced variables the estimation sample starts at 1985(1).

The monetary aggregate used in this paper is the official aggregate M3 of the ECB. A historical time series of this data was published by European Central Bank (1999). The definition of the monetary aggregate M3 of the ECB corresponds to a very broad monetary aggregate; it is broader than the aggregate M3 that was used previously for example by the German Bundesbank.[5] As the ECB implemented a new definition for M3, that contains different and new components such as

[4] An exact overview of the national data sources and of the time periods for which national data is estimated as well as the applied estimation methods, is given in the Tables 9 to 13 in Appendix B respectively.

[5] The monetary aggregate M3 of the ECB comprises currency in circulation, overnight deposits, deposits with agreed maturity up to 2 years, deposits redeemable at notice up to 3 months, repurchase agreements, money market fund shares/units and money market paper and debt securities up to 2 years.

money market funds and money market paper "a considerable amount of estimation was necessary, particularly for earlier dates" (European Central Bank (1999), p. 41). Furthermore, the ECB adjusted the national series for important structural breaks. For example, the impact of the German unification was straightened out of the time series. The national M3 series were then converted into Euro by the ECB using the irrevocably fixed conversion rates vis-à-vis the Euro which were determined on 31 December 1998. Thereafter the national series were added up. The M3 data was published as non-seasonally adjusted end-of-month data. We transformed the end-of-month data into end-of-quarter data by using the last month of each quarter as quarterly data. Afterwards the M3 data was seasonally adjusted applying Berlin Method (BV4).[6] Seasonal adjustment of M3 had to be applied for reasons of a consistent data set (see GDP construction below).

The main data source for the national real and nominal GDP data is Eurostat. We calculated real and nominal GDP, because the increase of the resulting implicit GDP deflator serves as an inflation rate. In periods where no national data was available estimations had to be carried out. If, for example, during a certain period Eurostat data for one country was missing, but data from the Organisation for Economic Cooperation and Development (OECD) was available, then we calculated the level of the Eurostat GDP data in the missing period using the growth rate of the OECD data. The national data relies on the European System of Accounts going back to 1979 (ESA 79) because for the harmonized and therefore more appropriate European System of Accounts after the convention of 1995 (ESA 95) no long time series are at hand. Furthermore, for some countries, such as France, only seasonally adjusted GDP data exists. Therefore we decided to use seasonally adjusted GDP data for all countries.

In analogy to the calculation of the monetary aggregate M3 by the ECB we adjusted the GDP series for the impact of the German reunification. The GDP data series for unified Germany which is applied in our analyses starts in 1989(1). Before that date no such data is available. We therefore estimated the GDP data for Germany for the period before 1989(1) assuming the growth rates of the West German GDP data. We then transformed the national GDP series into Euro currency using the fixed conversion rates vis-à-vis the Euro. After aggregating the national GDP series we obtained our EMU-GDP time series.

The national data of the long and short term interest rates are taken from the OECD Main Economic Indicators. The long term interest rates represent the yield of long term government bonds. Unfortunately, the rates of return of the government bonds published by the OECD for different countries do not reflect exactly the same maturities. For example, for Germany the yield on public sector bonds with 7 to 15 years duration is taken while for Italy the yield on treasury bonds of maturity of one year or more is included.

Against that, the short term interest rates refer exactly to the same maturities in all countries.

[6] BV4 is the abbreviation of the German name Berliner Verfahren Version Nummer 4 which stands for Berlin Method version number 4. See Nourney (1993) for a description.

They measure the yield of three-month inter bank deposits which is represented for instance in Germany by the three-month FIBOR or in France by the three-month PIBOR. The national interest rate series are constructed as end-of-quarter data. They are weighted with their current share of EMU-GDP to obtain the EMU interest rate series. In years where no interest rate data for a particular country was available the interest rate of this country does not enter into the calculation. The inflation is measured as quarter on quarter increase of the GDP deflator.

4 Cointegration Analysis

In this chapter a cointegration analysis is carried out. After analysing the stationarity properties of our variable set, we will discuss our general modelling approach, then turn to determining the cointegrating rank of our system and finally, try to identify the cointegration vectors as well as their stability properties.

4.1 Data Properties

Knowledge about the stationarity properties of the data underlying the investigation is crucial to the choice of the appropriate econometric methods. Therefore, in a first step we conducted unit root tests for the five variables under consideration to discriminate between trend stationary and difference stationary variables.

From the results achieved with the Augmented-Dickey-Fuller (ADF) tests and the Phillips Perron (PP) tests shown in Table 1 we conclude that all variables are non-stationary (or to be more precise integrated of order one, I(1)).[7] Visual inspection of the time series shown in Figure 2 in the data appendix seems to support our conclusions.

4.2 The General Model

Following the considerations outlined previously, we investigate a very general macro-economic model by means of a vector auto-regressive process of the form

$$X_t = D + \sum_{i=1}^{k} A_i X_{t-i} + E_t \tag{3}$$

where X_t is a $(n \times T)$ matrix of our n variable series $(x = [(m-p)\ y\ i^l\ i^s\ \triangle p]')$ with $T = 54$ observations each. E_t is a vector of error terms assumed to be distributed $E_t \sim (0, \Xi)$. The vector D collects the constant terms. Economic structure enters the setup when the sample of integrated variables exhibits cointegration features such as for example in equation (2). That means finding long-run relationships between the variables we will have to check whether or not they comply to the

[7] Calculations were performed with the software packages *PcFiml* (see Doornik and Hendry (1997)), *GAUSS* and *EViews 2.0*.

Table 1: Unit root tests (1985(1) - 1998(2))

Variable	Notation	ADF Test[+]		PP Test		5 Percent	Decision
		Setup[++]	Statistic	Setup[++]	Statistic	Crit. Val.[+++]	
$log(M3/P)$	$m-p$	c,t,1,3,4,5	-1.51	c,t,3	-0.91	-3.50	I(1)
$\triangle log(M3/P)$		c,3,4	-2.57	c,3	-3.86*	-2.91	
$log(GDP)$	y	c,t,1,2	-2.09	c,t,3	-1.64	-3.50	I(1)
$\triangle log(GDP)$		c,1,4	-2.42	c,3	-5.04*	-2.91	
i^l	i^l	c,1	-1.11	c,3	-0.75	-2.91	I(1)
$\triangle i^l$		c,1,5	-4.08*	c,3	-4.53*	-2.91	
i^s	i^s	c,1	-1.05	c,3	-0.91	-2.91	I(1)
$\triangle i^s$		c	-5.29*	c,3	-5.18*	-2.91	
$\triangle log(P)$	$\frac{1}{4}\pi$	c,1,4	-1.19	c,3	-2.30	-2.91	I(1)
$\triangle^2 log(P)$		c,2	-11.19*	c,3	-11.29*	-2.91	
$i^l - i^s$		c,1,4	-2.50	c,3	-1.89	-2.91	I(1)
$\triangle(i^l - i^s)$		c,3	-5.84*	c,3	-5.96*	-2.91	
$i^s - 4\triangle p$		c	-2.32	c,3	-2.24	-2.91	I(1)
$\triangle(i^s - 4\triangle p)$		c	-9.22*	c,3	-9.21*	-2.91	
$i^l - 4\triangle p$		c	-3.64*	c,3	-3.74*	-2.91	I(0)

* indicates significance at the five percent level

+ The sample size had to be adjusted according to the setup in some cases.

++ c: constant, t: trend, the integers indicate the lags of differenced dependent variables included in the regression (ADF test) and the truncation lag (PP test)

+++ MacKinnon (1991) critical values

concept of money demand for example. We therefore turn to a cointegration analysis in the Johansen reduced rank framework by rewriting (3) to obtain

$$\triangle X_t = \Theta + \Pi X_{t-1} + \sum_{i=1}^{k-1} \Gamma_i \triangle X_{t-i} + E_t \tag{4}$$

with $\triangle = (1 - L)$ and L being the lag or backshift operator ($LX_t = X_{t-1}$). For details of the relationship between the A_i, D and Γ, Π, Θ matrices see e.g. Lütkepohl (1993). The interesting term on the r.h.s of (4) is the matrix Π which has reduced rank if the variables are cointegrated. This matrix Π potentially contains information about long-run relationships of the variables under consideration. We now investigate its properties.

4.3 Determination of the Cointegrating Rank

From a theoretical perspective three linearly independent cointegration relationships could have been expected. Next to a stationary money demand function theory suggests the interest rate spread as well as the real interest rates might prove to be stationary. The assumption of a stationary spread is derived from the expectation hypothesis of the term structure. According to this hypothesis the long term interest rate is determined by the average of the present and the expected future short term interest rates. Therefore, except for a risk premium[8], the yield of the longer term investment should

[8] Economic theory suggests this premium to be stationary.

equal the yield of several short term investments that together cover the same period. Finally, the idea of stationary real interest rates refers to the Fisher parity, which explains the frequently observed positive correlation between interest rates and the inflation rate. Higher inflation reduces the real yield of nominal assets compared to real assets which via higher demand for credits induces nominal interest rates to increase. We keep in mind these theoretical proposals for the potential cointegration relationships when we now turn to the determination of the actual cointegrating rank of our system.

Noting the dependence of the performance of cointegration tests on the number of observations available we not only perform one test at a certain lag length but also vary the number of lagged endogenous variables and consider subsystems.[9] That is, starting with a maximum lag length of three, which seems to be reasonable given 58 observations (54 observations from 1985(1) to 1998(2) and four pre-sample data points) in our sample and five variables under investigation, we reduce the number of lags down to one and do so for three models. These are the full model (five variables), a model which excludes inflation and a third, which consists of real money, income and the long term interest rate only.

Table 2 reports the cointegrating ranks chosen in a sequential test procedure by three different tests at the five and ten percent level of significance. The three tests are the well known Johansen (1995) likelihood-ratio test (LR^J, trace statistic), another LR test with trend adjustment and a maximum likelihood (LM) type test, both of which have been suggested by Lütkepohl and Saikkonen (2000). The relative performance of all these tests has been analysed e.g. by Hubrich et al. (1998). In Table 2 it can be seen that the cointegrating rank of the full system seems to be two. At lag length two for example, there is unanimous evidence in favour of that, although at the ten percent level only for the Johansen test. The corresponding test results for lag order two are given in Table 5 in the appendix A. When the inflation variable ($\triangle p$) is excluded, all tests report in most cases one cointegrating rank only. Almost no evidence in support of any cointegration is found when a system of money, income and a long term interest rate is considered. When evaluating the test results one should have in mind that the loss in power often becomes substantial when the degrees of freedom are rather low, which is the case with the current sample at lag length three already (five and four variables). The size, on the other hand, often tends to exceed its nominal level if the true lag length has been understated.

Fortunately, our experiment gives a relatively consistent picture, that is, the full system is cointegrated of order two, where one of the cointegration relationships requires inclusion of the inflation variable and the second includes money, income and possibly long and short term interest rates. Therefore, from an economists point of view we expect one relationship relating money to income and probably interest rates and a second one might link e.g. long term interest rates and inflation to yield some stationary real interest rate.

[9]See Reimers (1991), Yap and Reinsel (1995), Saikkonen and Luukkonen (1997) and Hubrich, Lütkepohl and Saikkonen (1998) on the properties of cointegration tests with varying lag order and dimension. A general outcome is the remarkable deterioration of power when the lag length and/or dimension of the system becomes larger.

Table 2: Cointegration Test: Ranks selected by various tests*

$\triangle X_t = \Theta + \alpha\beta' X_{t-1} + \Sigma_{i=1}^{k-1}\Gamma_i \triangle X_{t-i} + E_t$

k	LR^J	LR^{ta}	$LM(r_0)(it)$
$X' = ((m-p), y, i^l, i^s, \triangle p)$ full model			
1	1 (2)	1	1
2	1 (2)	2	2
3	1	2	1
$X' = ((m-p), y, i^l, i^s)$ inflation excluded			
1	1 (2)	1	1
2	1	1	0
3	0	0	0
$X' = ((m-p), y, i^l)$ basic money demand			
1	0(1)	1	0
2	0(1)	0	0
3	0	0	0

* The columns report the ranks selected at the 5 % level of significance and at the 10% level in brackets if there is a difference.
A sequential test procedure and trace statistics are applied.
LR^{ta} refers to a Johansen like test on the adjusted series $\tilde{x}$ in Lütkepohl and Saikkonen (2000), p.184. $LM(r_0)(it)$ refers to Lütkepohl and Saikkonen (2000), eq. 4.10, two-step procedure for estimating μ_0 and μ_1, it indicates iterative variant.

Before turning to the actual identification of the cointegration matrix a note on the choice of the lag length is in order. Starting again at a maximum length of three we perform F-tests of parameter reduction and apply order selection criteria. While the Schwarz Criterion (SC), Hannan-Quinn Criterion (HQ) and Akaike Information Criterion (AIC) all point to different lag lengths, the F-tests imply that a reduction from three to two lags, yet not further, is acceptable (see Tables 6 and 7 in the appendix A). We therefore continue the analysis with two lags, a decision which also finds support from a number of specification tests, almost none of which indicate serious problems (Table 8). Working with two lags ($k = 2$) in the VAR representation of equation (3) also ensures a parsimonious parametrisation.

4.4 Identification of Cointegration Vectors

In this section, the cointegration relationships are to be identified. Out of the three hypothesized cointegration relationships, the interest rate spread has already been found to be non stationary but the long term real rate seems to be stationary (see Table 1). In the following we will refer to this result.

Determining the cointegration vectors we make use of the reduced rank property of the cointegrating matrix, namely that it can be separated into two matrices of full column rank as it has become common procedure since Johansen (1988). We define $\alpha\beta' = \Pi$ with α and β of dimension $(n \times 2)$ and

Table 3: Identifying the cointegration relationships

step	*vector*	$m-p$	y	i^l	i^s	$\triangle p$
1	β_1	1	-1.505	2.422	-1.657	0
			(.04)	(.45)	(.32)	
	α'_1	-0.063	0.111	0.005	-0.03	-0.018
		(.03)	(.03)	(.03)	(.05)	(.01)
	β_2	0	0	1	0	-5.253
						(.57)
	α'_2	0.046	-0.218	-0.075	0.050	0.143
		(.07)	(.07)	(.08)	(.12)	(.03)
2	β_1	1	-1.574	3.405	-2.061	0
			(.05)	(.57)	(.36)	
	α'_1	-0.035	0.111	0	0	0
		(.02)	(.02)			
	β_2	0	0	1	0	-4
	α'_2	0	-0.295	0	0	0.129
			(.07)			(.03)

β contains the long-run parameters while α represents the short run adjustment coefficients to the actual values of the cointegration relationship of each variable in the system. The task is now to find appropriate restrictions on α and β which together identify the matrix Π.

Restating one of the results of the previous section we begin our identification procedure by imposing a cointegrating relationship which includes long term interest rates and the changes in the price level. Having in mind the Fisher parity of the form

$$r = i^l - \pi^{exp}, \tag{5}$$

where r represents some stationary long term real interest rate and π^{exp} is short for an inflation expectation, we would expect π^{exp} to be around four times the value of $\triangle p$ in case individuals base their inflation forecast on past levels of the annual rate and consider this to be the best possible expectation. In addition, individuals would regard the inflation forecast relevant for their decision to be a linear function of the quarterly price changes, e.g. four times the value of the quarterly changes in order to approximate the annual rate.

The second linearly independent cointegrating vector obviously must not include either quarterly price changes or long term interest rates. In line with the common specification we include interest rates. In addition to the long-run parameters, we look at the significance of the short-run adjustment parameters by comparing their point estimates with the respective standard error. At the final identification stage we apply Wald tests to check whether or not the restrictions imposed on Π are too strong compared with the unidentified reduced rank matrix.

Table 3 summarizes the estimation results.[10] Parameters have been dropped, when their standard deviation clearly exceeded half the absolute value of the point estimate. When a coefficient is dropped,

[10] To save space we do not report all intermediate results.

its value is set to zero, in this case as well as in the cases where parameters serve scaling purposes or are set to equal certain values, no standard deviation is reported.

In the first step one relationship is defined such that it may reflect a money demand function and the other possibly represents the Fisher parity. Therefore in the first vector changes in prices are excluded while in the second, only the coefficients on long term interest rates and the change in prices are estimated. As a result the first relationship's estimates are convincingly in line with a money demand function. This is true with respect to both the sign and magnitude of the parameter estimates. In addition they all seem to be statistically significant. The second relationship yields a coefficient on price changes of -5.25 being not very far from the -4 which is to be expected following the discussion above.

Finally, we set a number of adjustment parameters to zero according to the criteria mentioned above. Additionally we restricted the parameter of the inflation variable in the "Fisher equation" to -4 and performed a Wald test on whether or not all the restrictions imposed in the second step are statistically significant. The corresponding χ^2 statistic with 9 degrees of freedom yields 14.49 with a marginal probability of 11%.

Hypothesising this outcome to be robust throughout time, we recursively estimated the parameters of α and β except from those which had been previously restricted. We do not find evidence of either instability of the long-run coefficients or of rejection of the restrictions at any point in time between 1992(4) and 1998(2). To demonstrate this property in Figure 1 we provide a graphical analysis by collecting the recursive estimation results for the freely estimated coefficients and the Wald statistic, together with the estimated cointegration relationships as well as the eigenvalues of the unrestricted system.

We conclude

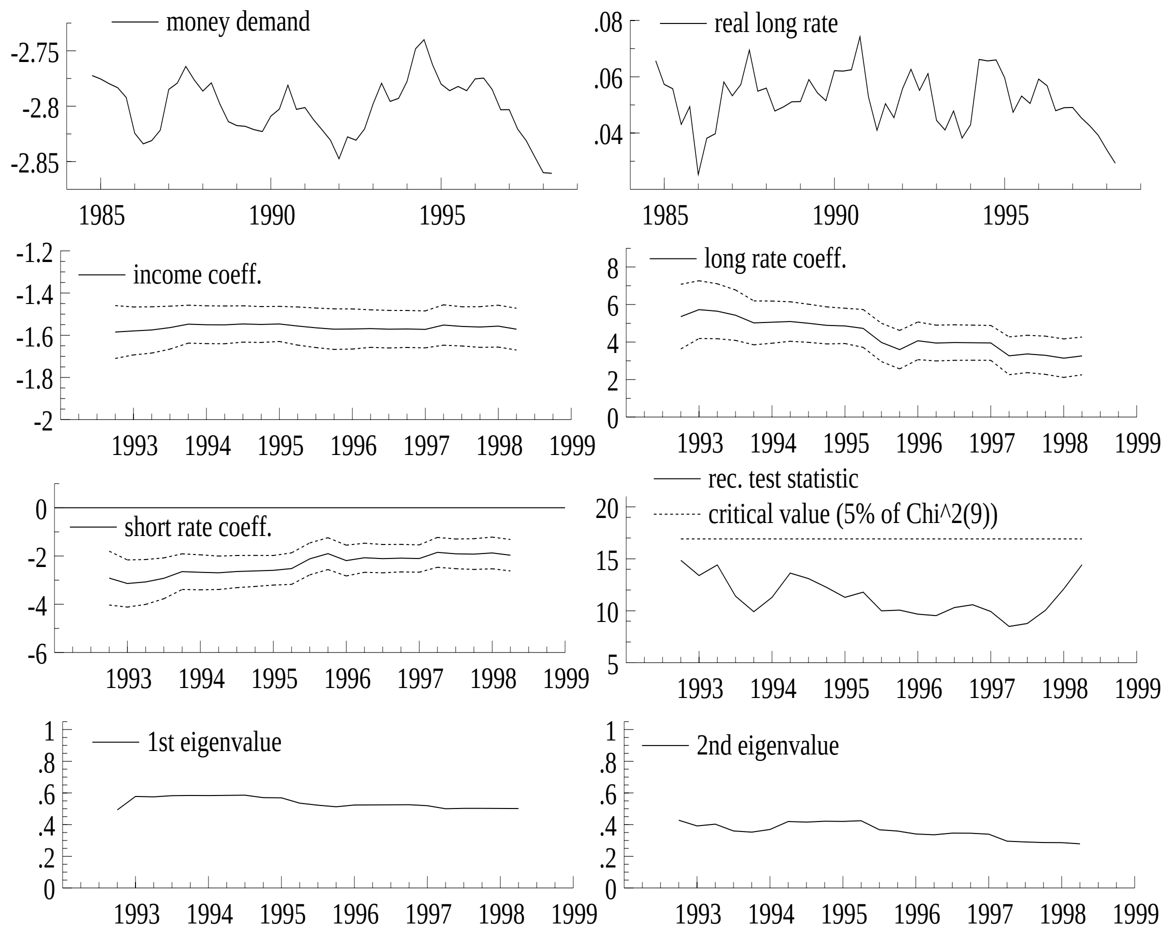
$$m - p = 1.574y - 3.405i^l + 2.061i^s \qquad \text{and} \tag{6}$$

$$i^l = 4\triangle p \tag{7}$$

to be valid and stable restrictions of the cointegration space representing stationary relationships of the non-stationary data. The first of them (6) may well be interpreted as a money demand relationship in line with (2). Here, the income elasticity is nearly 1.6 being consistent with a trend decline of the velocity of circulation in a monetarist framework. Interest rates either induce money holdings to decrease when the opportunity costs, measured by the long term rates, increase, or to expand when assets inside the broad monetary aggregate promise higher returns. The respective coefficients are of similar magnitude, although money seems to be more sensitive with respect to long term interest rates.

A stationary interest rate spread as proposed by the expectation theory of the term structure could not be identified within our system, although the graphical analysis of the interest rates (see Figure 2 in the appendix B) points to the direction that the expectation theory could hold. The lack of a

Figure 1: Stability of the long-run relationship over time



Cointegration relationships; recursively estimated coefficients together with two standard error bands on income, long and short term interest rates; recursive test of restrictions; recursive eigenvalues

cointegration relationship between the long and short term interest rates could be due to distortions caused by the convergence process that took place within our data sample as was discussed above. Especially the efforts to achieve convergence in the short term interest rates in recent years could have contributed to that deficiency. Nonetheless from an econometric point of view our cointegrating results are consistent. In the framework of a stationary long term real interest rate and a non-stationary short term real interest rate logic requires the interest rate spread to prove as non-stationary.

Comparing our results with studies for the same countries, a similar variable set and econometric approach, consensus can be found on the general outset of the money demand equation, its components and the dimension of the coefficients on interest rates as well as stability properties. In contrast to these studies, however, the income elasticity of money demand found in our model is clearly greater than unity. To some extent these differences arise because of different sample sizes[11] and different

[11] Coenen and Vega (1999) investigate a period from 1980(1) till 1998(4) and Gottschalk (1999) starts at 1983(1),

Table 4: Comparing estimates of European money demand functions

recent result	$(m-p)$	$=$	$1.57y - 3.41i^l + 2.06i^s + ec^m$
Coenen and Vega (1999)	$(m-p)$	$=$	$1.14y - 0.82(i^l - i^s) - 5.84\triangle p + ec^{m,CV}$
Gottschalk (1999)	$(m-p)$	$=$	$y - 3.16i^l + 4.83i^s + ec^{m,G}$

data sources. The latter cannot be named in detail due to missing information. Further reasons for the differences are different cointegrating ranks[12] and different aggregation methods.[13]

Interpretation of the short-run adjustment coefficients (α components) reveals that interest rates seem to be weakly exogenous with respect to money, which would imply interest rates to be a useful tool in the hands of monetary authorities, because the rates apparently do not systematically react to the stance of money demand yet seem to have quite an impact on the preferred level of money holdings. On the other hand, the adjustment coefficient of the money demand equation seems to be rather small, challenging the view of rational individuals adjusting their money balances according to the actual conditions of the long-run relationship at all. Some insight into the significance of this coefficient has been gained by re-estimating the system with the seemingly unrelated regression procedure (see Zellner (1962)) with fixed zero restrictions on α and fixed β vectors according to equations (6) and (7). Doing so, the coefficient yields a t-value of 2.00. We therefore conclude this to be a small but marginally significant coefficient. In any case stability of the long-run parameters is what matters most, the short-run adjustment coefficients are usually regarded less important for strategic policy decisions. Moreover, a missing adjustment of money stock to money demand imbalances does not automatically imply monetary targeting to be infeasible. In the short-run, there may well be a reaction of money demand to a change in the instrument. What is noteworthy though, is the positive link between short term rates and money stock. This link suggests that money increases in the long-run when the central bank raises interest rates. In contrast to Coenen and Vega (1999) who report existence of an interest rate channel (stationary interest rate spread) we cannot argue that increasing short rates will necessarily result in higher long rates and thus force money stock to decline. Our findings hint to a re-adjustment through the change in income, which as a consequence of rising short rates will decrease in the long run ($\alpha_{1,y} = 0.11$). Finally, lower income results in lower demand for money.

5 Conclusions

In light of the discussion about the information content of pre-EMU estimation results to the current situation we have to be cautious about deriving too detailed policy implications. From a theoretical

finishing in 1997(2).

[12]Coenen and Vega (1999) find a stationary interest rate spread as a third relationship.

[13]Coenen and Vega (1999) apply fixed weights and base year PPP for aggregation and conversion while Gottschalk (1999) uses fixed exchange rates.

point of view the question has to be raised as to what extent the convergence process for the EMU influences our estimation results. This might be a more serious problem with respect to the short term adjustment estimates (α, Γ_i coefficients, equation (4)) than for the long-run relationships identified. The stability analysis on the one hand investigates the impact of new information being available while approaching the Euro date. It is therefore fair enough to conclude that, since nothing has changed significantly in that period, the relationships we are interested in are stable. On the other hand, however, the final estimation results might be too much distorted by very early observations which are allowed to have the same impact as the more recent one. There is certainly no easy solution to control for this.

Noting the discrepancy between short and long-run adjustment coefficients (α, Γ_i versus β in equation (4)) in terms of the rate of convergence we do not yet push the analysis beyond the long-run investigation.[14] We would be ready to do so, however, if two very principal conditions are fulfilled. The first one is to find an appropriate estimation scheme that accounts for the adjustments made in preparation for the Euro. This could be done for example by weighing earlier observations less when across country variability e.g. of inflation rates is high or by estimating panel data models. The latter unfortunately does not seem to be promising due to an apparent imbalanced proportion between both the number of reliable data points and their respective parameters which have to be estimated.

The second condition is stability of all the short-run coefficients e.g. because the actual shape of impulse response curves depend on these coefficients as well.

To sum up, before the difficult background of analysing aggregated data we find two stable long-run relationships within a set of variables comprising a broad monetary aggregate, real income, long and short term interest rates and prices. One of these relationships is in line with the long-run real interest rate (Fisher parity) whereas the second implies the existence of a stable money demand at the EMU level. The coefficients of the long-run money demand compare favourably with those of other studies, except for the income elasticity of money demand. Its magnitude of 1.6 exceeds unity considerably. We relate this finding to the trend decline in the velocity of circulation. Although apparently small, adjustment of money to deviations from the long-run money demand equilibrium seems to take place. Moreover interest rates are weakly exogenous and can therefore, in the longer run be used for policy making such as targeting money.[15]

We have tested the stability of the long-run parameters along with the weak exogeneity properties and have found them to be stable over a period of almost six years before the start of the EMU. Our findings provide no evidence against monetary targeting as applied by the ECB as one of the two pillars of its monetary strategy.

[14] This could be done by impulse-response analysis for example to model the impact of policy measures as in Coenen and Vega (1999).

[15] See Ericsson (1999) for a discussion of weak exogeneity implications.

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A Tables Appendix

Table 5: Cointegration Tests

$$\triangle X_t = \Theta + \alpha\beta' X_{t-1} + \sum_{i=1}^{1} \Gamma_i \triangle X_{t-i} + E_t$$

H_0 $r=0$	LR^J trace statistic	critical values 5%	critical values 10%	LR^{ta} trace statistic	$LM(r_0)(it)$ trace statistic	critical values$^+$ 5%	critical values$^+$ 10%
0	85.16**	68.5	64.7	93.74**	71.71**	65.7	61.8
1	45.65*	47.2	43.8	51.93**	51.48**	45.1	42.0
2	19.95	29.7	26.7	16.72	23.08	28.5	25.9
3	6.85	15.4	13.3	6.42	8.21	15.9	13.9
4	0.16	3.8	2.7	0.78	1.74	6.8	5.4

*, ** indicate significance at the ten and five percent level respectively (LR^J calculation: $EViews$).

$^+$ critical values apply to LR^{ta} and $LM_2^1 it$ statistics

Table 6: Lag-Order Determination (1)

$$X_t = D + \sum_{i=1}^{k} A_i X_{t-i} + E_t$$

lag order(k)	AIC	SC	HQ
1	-56.29	-55.62*	-56.29
2	-57.18	-55.11	-56.36*
3	-58.04*	-54.13	-55.94

* indicates the minimum of the column

Table 7: Lag-Order Determination (2)

$$X_t = D + \sum_{i=1}^{k} A_i X_{t-i} + E_t$$

H_0 vs. H_1	d.f.	F-statistic$^+$
$k=3$ vs. $k=2$	25,127	1.33 (.15)
$k=3$ vs. $k=1$	50,158	1.97 ** (.00)
$k=2$ vs. $k=1$	25,146	2.56 ** (.00)

* (**) indicates significance at 5 (1) percent

$^+$ marginal level of significance in brackets

Table 8: Residual Analysis, $VAR(2)$

$$X_t = D + \sum_{i=1}^{k} A_i X_{t-i} + E_t$$

Test**	Residuals of single equations						Vector	
	d.f.	$(m-p)$	y	i^l	i^s	$\triangle p$	d.f.	X
observ.	-	54	54	54	54	54	-	-
AR(1-4)	F(4,39)	1.86 (.14)	0.88 (.48)	0.22 (.93)	0.78 (.55)	3.40 * (.02)	F(100,97)	1.52 (.24)
NORM	$\chi^2(2)$	1.10 (.58)	2.26 (.32)	0.38 (.83)	0.37 (.83)	1.41 (.49)	$\chi^2(10)$	4.35 (.93)
ARCH(1-4)	F(4,35)	1.05 (.40)	0.19 (.94)	0.58 (.68)	0.58 (.68)	.89 (.48)	-	-
Mis-spec	F(20,22)	0.57 (.90)	0.65 (.83)	0.45 (.96)	0.65 (.83)	0.32 (.99)	F(300,140)	0.57 (1.00)

AR(1-4) tests significance autocorrelation of up to four lags, ARCH(4) tests for presence of autoregressive heteroscedasticity in the residuals up to order 4, NORM is the Jarque-Bera test for normality, Mis-spec tests for general mis-specification.

* indicates significance at 5 percent significance level

** marginal level of significance in brackets

B Data Appendix

Figure 2: Data Graphics

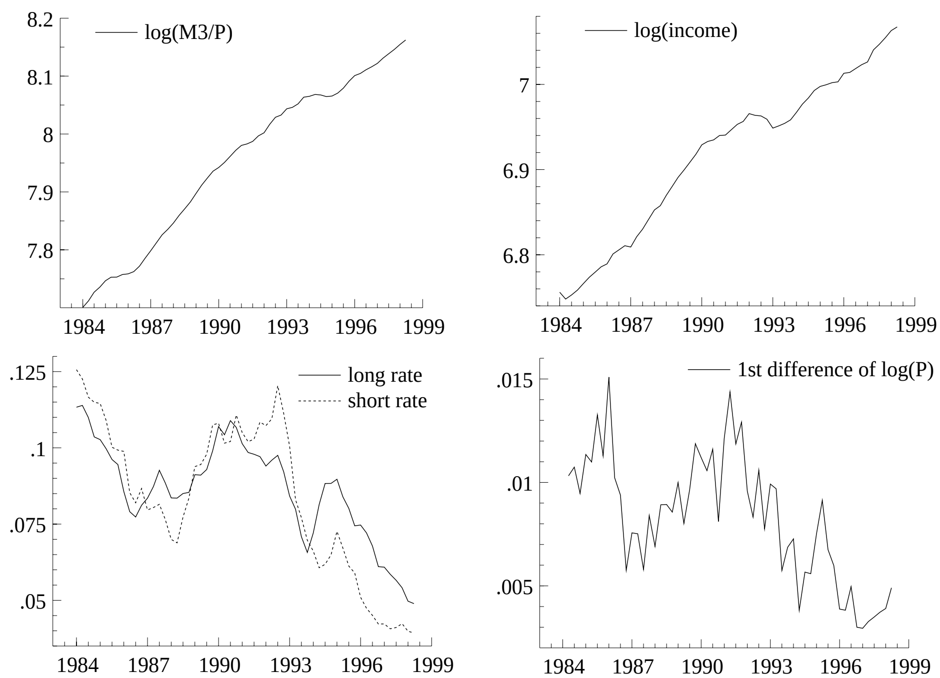

Table 9: Sources and periods of coverage of the monetary aggregate M3

Country	Source I MFI balance sheet statistics	Source II Best estimates of national contributions to the Euro area aggregates	Source III National monetary aggregates (national non-harmonised data)
Belgium	As from December 1996	January 1980 to November 1996	
Germany	As from January 1980		
Spain	As from January 1980		
France	As from January 1980		
Ireland	As from September 1997	December 1995 to August 1997	January 1980 to November 1995
Italy	As from December 1995	January 1980 to November 1995	
Luxembourg	As from September 1997	January 1980 to August 1997*	
Netherlands	As from December 1990	December 1982 to November 1990	January 1980 to November 1982
Austria	As from November 1996**	January 1980 to October 1996	
Portugal	As from January 1980		
Finland	As from January 1980		

* Estimated by applying the EU10 growth rates.
**Includes interpolations for the period from November 1996 to August 1997.
SOURCE: ECB (1999), Monthly Bulletin February, p. 42.

Table 10: Sources and periods of coverage of the nominal GDP

Country	Source I Eurostat	Source II other
Belgium	As from 1985	The data for the year 1984 is calculated on the basis of the the average growth rates of the other EMU countries.
Germany		The data has been supplied by the German Institute for Economic Research (DIW), Berlin. For the period prior to 1989 the data for unified Germany is calculated on the basis of the growth rates of the former West Germany.
Spain	All	
France	All	
Ireland		For the period before 1990 the data is calculated on the basis of the the the average growth rates of the other EMU countries. As from 1990 the data of the German Institute for Economic Research is taken.
Italy	All	
Luxembourg		For the period prior to 1990 the data is calculated on the basis of the average growth rates of the other EMU countries. As from 1990 the data of the German Institute for Economic Research is taken.
Netherlands	As from 1990	For the period before 1990 to the data is calculated on the basis of the growth rates of Eurostat data.
Austria	All	
Portugal	As from 1986	For the period prior to 1986 the data is calculated on the basis of the average growth rates of the other EMU countries.
Finland	All	

Table 11: Sources and periods of coverage of the real GDP

Country	Source I Eurostat	Source II other
Belgium	As from 1985	The data of the year 1984 is calculated on the basis of the growth rates of OECD data.
Germany		The data has been supplied by the German Institute for Economic Research (DIW), Berlin. For the period before 1989 the data for unified Germany is calculated on the basis of the growth rates of West Germany.
Spain	All	
France	As from 1990	For the period prior to 1990 the data is calculated on the basis of growth rates of Eurostat data.
Ireland		For the period before 1990 the data is calculated on the basis of the extrapolated share of 9 EMU countries (EMU except for Irland and Luxembourg). As from 1990 calculations of the German Institute for Economic Research on the basis of indicators and the yearly GDP data of the OECD are used.
Italy	All	
Luxembourg		For the period prior to 1990 the data is calculated on the basis of the extrapolated share of 9 EMU countries (EMU except for Irland and Luxembourg). As from 1990 calculations of the German Institute for Economic Research on the basis of indicators and the yearly GDP data of the OECD are used.
Netherlands	As from 1990	For the period before 1990 the data is calculated on the basis of the growth rates of Eurostat data.
Austria	As from 1990	For the period prior to 1990 the data is calculated on the basis of the growth rates of Eurostat data.
Portugal	As from 1988	For the period before 1988 data is calculated on the basis of growth rates of International Monetary Fund data.
Finland	All	

Table 12: Definitions of the national long-term interest rates

Country	Long-term interest rate
Belgium	Yield of government bonds (6-years and over) on the secondary market.
Germany	Public sector bond yield, that refers to long-term public bonds (7 to 15 years duration) on the secondary market.
Spain[1]	Yield on 10 year government bonds, with the exception of 1994 for which the data refers to 9 year government bonds.
France	Yield on long term public sector bonds on the secondary market.
Ireland	Yield on government securities of 15 years to maturity.
Italy	Yield on Treasury bonds of maturity of one year or longer.
Luxembourg	No data available.
Netherlands	Yield on the five longest term central government bonds.
Austria	Yield on bonds of maturity of one year or more on the secondary market.
Portugal[2]	Yield on 10-year government debt bonds on the secondary market.
Finland[3]	Yield of 3 to 6 year taxable central government bonds on the secondary market.

SOURCE: OECD (1997) Main Economic Indicators, Sources and Definitions, July.
[1]Data not available for the period 1984(1) - 1986(4).
[2]Data not available for the period 1984(1) - 1994(4).
[3]Data not available for the period 1984(1) - 1987(4).

Table 13: Definitions of the national short term interest rates

Country	Short-term interest rate
Belgium	3-month Treasury Certificates
Germany	3-month FIBOR
Spain	3-month interbank loans
France	3-month PIBOR
Ireland	3-month interbank rate
Italy	3-month interbank rate
Luxembourg	No data available.
Netherlands[1]	3-month AIBOR
Austria[2]	3-month VIBOR
Portugal[3]	86-96 day interbank rate
Finland[4]	3-month HELIBOR

SOURCE: OECD (1997) Main Economic Indicators, Sources and Definitions, July.
[1]Data not available for the period 1984(1) - 1985(4).
[2]Data not available for the period 1984(1) - 1988(4).
[3]Data not available for the period 1984(1) - 1985(2).
[4]Data not available for the period 1984(1) - 1986(4).